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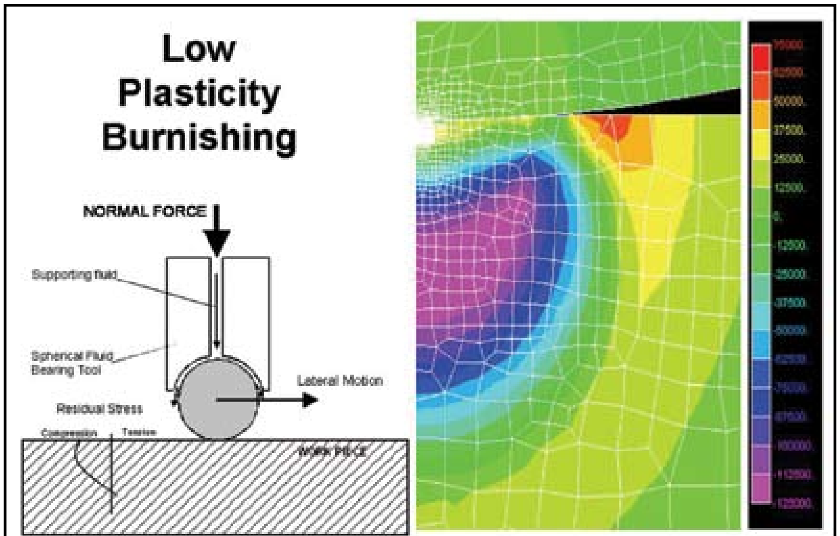
Science and Technology for Tomorrow's Air and Space Force

SUCCESS STORY

Air Force SBIR/STTR

LOW-PLASTICITY BURNISHING ENHANCES TURBINE ENGINE DURABILITY



LPB Processing Schematic and Associated FEM Simulation

AFRL and Lambda Research, Inc., studied an innovative surface treatment technology to reduce turbine engine inspection costs and maintenance and extend engine components' operating life. The team conducted research under a Small Business Innovation Research (SBIR) contract and revealed that low-plasticity burnishing (LPB) can introduce deep, compressive residual stresses similar to those resulting from other advanced surface treatment processes, such as laser shock processing (LSP). LPB surface treatment provides an effective means to improve fatigue performance, particularly damage tolerance, in both new and legacy aircraft engines, ground-based turbines, and other fatigue-sensitive hardware. In addition to enhancing materials selection and design, the LPB treatment also offers the turbine designer a means to improve turbine engine component durability at lower costs.

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Accomplishment

Under the SBIR project, AFRL, Lambda Research, the Naval Air Systems Command, and the National Aeronautics and Space Administration teamed to demonstrate the benefits of LPB surface treatment. The team confirmed that LPB provides a thermally stable layer of compressive residual stresses of comparable magnitude to--and even greater depth than--either shot peening or LSP. This result dramatically improves the fatigue performance of complex turbine engine hardware without altering either alloy or design. The studies also successfully demonstrated that users can perform LPB in conventional machine shop environments using computer numeric control (CNC) machine tools. The research effort also demonstrated that LPB can improve performance in numerous fatigue applications, including foreign object damage (FOD), stress corrosion cracking, fretting, welded joints, and biomedical implants.

Background

Many fatigue mechanisms, including high-cycle fatigue (HCF), FOD, corrosion fatigue, and fretting fatigue limit the life span of turbine engines, power systems, and aerospace structures. Until recently, HCF alone accounted for more than half of all major aircraft engine failures. Scientists demonstrated that deep compressive stresses, induced by LPB and other processes, can suppress many of these failure mechanisms.

The basic LPB tool consists of a ball supported in a spherical hydrostatic bearing. Any lathe or mill can hold the tool. The machine tool coolant pressurizes the bearing with a continuous flow of fluid to support the ball. The ball does not contact the bearing seat, even under load, and is loaded normal to the component's surface with a hydraulic cylinder in the tool's body. Users can perform LPB in conjunction with chip-forming machining operations in the same CNC machine tool. The ball rolls across the component's surface in a pattern defined in the CNC code, as in any machining operation. The treated hardware can be extremely complex. The pressure from the ball causes plastic deformation in the material surface under the ball. Since the bulk of the material constrains the deformed area, the deformed zone is left in compression after the ball passes. There is no material removal in the process, and the surface experiences inward displacement by only a few ten-thousandths of an inch. The design of the tool path and the normal applied pressure create a carefully engineered distribution of compressive residual stress, and the design of distribution counters applied stresses and optimizes fatigue performance.

Materials and Manufacturing
Emerging Technologies
(Sustainment)

Additional Information

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